

REVIEW ARTICLE

Shift Work and Cancer

The Evidence and the Challenge

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SUMMARY

Background: In 2007, the International Agency for Research on Cancer (IARC) classified shift work with circadian disruption or chronodisruption as a probable human carcinogen. Short-term disturbances of biological 24-hour-rhythms following exposures to light and darkness at unusual times are well-known as „jet-lag“ and „shift-lag“ symptoms. However, that chronic disturbances or disruptions of timely sequenced circadian rhythms (chronodisruption) should contribute to long-term developments of cancer is a relatively new concept. This review provides background and practical information with regard to the open question „does shift-work cause cancer?“

Methods: Overview on the basis of a selective literature search via Medline and ISI Web of Knowledge until 2009 from the viewpoints of occupational medicine, epidemiology, chronobiology, and occupational science.

Results: The postulated causal links between shift-work and cancer in humans are biologically plausible in the light of experimental findings, but to date we lack epidemiological studies which could describe or exonerate risks in humans. Monetary compensation has already been paid for such cases in at least one country (Denmark). In Germany, however, according to the applicable law, a new occupational disease can only be recognized when certain conditions for the recognition of „general scientific merit“ have been met. We present the current state of knowledge regarding prevention.

Conclusion: While causal links between shift-work and cancer developments are not established, future shift-work planning should pay more attention to insights from occupational medicine, chronobiology, and occupational science.

In October 2007, the International Agency for Research on Cancer (IARC) classified shift work with circadian disruption or chronodisruption as a probable human carcinogen (group 2A carcinogen) (1). This classification resulted from the IARC's assessment that, although the evidence for a carcinogenic effect in man is currently „limited,“ the evidence from animal experiments is already adequate.

As the IARC is a component agency of the World Health Organization (WHO), its monographs on cancer risks are widely read and appreciated. The current classification of certain types of shift work as „probably carcinogenic to humans“ places them in the same risk class as, e.g., ultraviolet radiation, benzo(a)pyrene, and acrylamide.

It has been known for years that short-term disturbances of circadian rhythms can cause health problems such as fatigue, insomnia, mood fluctuations, lack of appetite, and generally impaired performance: these phenomena are found in the well-recognized entities of „jet lag“ and „shift lag.“ The underlying pathophysiological mechanism is that exposure to light and darkness at unusual times leads to disruption of the normal sleep-wake rhythms. The observed changes are usually short-term and reversible, affecting (among other things) the affected persons' times of peak activity and of eating, as well as their cycles of hormone production and body temperature. On the other hand, it was proposed only relatively recently that an elevated risk of cancer might arise from chronic disturbances or disruptions in the temporal organization of biological 24-hour rhythms that normally run in parallel and that couple the individual to the daily alternation of light and darkness, and of day and night. This has been synthesized in the chronodisruption-cancer theory (2, 3).

In this article, we will sketch the relevant experimental findings, then explore in greater detail the epidemiological findings that shed light on the potential importance of this carcinogenic mechanism in man. We will present the current state of knowledge regarding risk communication and possible approaches to compensation and prevention, and, finally, we will provide perspectives on future developments. This critical review of the subject is based on a selective search of the literature up to 2009 that was performed in Medline and the ISI Web of Knowledge.

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TABLE 1

Meta-analyses of the risk of breast or prostate cancer in flight personnel (4)

	Number of studies	RR (95% CI), fixed effects	RR (95% CI), random effects
Breast cancer			
All studies	12	1.7 (1.4–2.1)	1.7 (1.4–2.1)
Cohort studies	9	1.6 (1.3–2.0)	1.6 (1.3–2.0)
Case-control studies	3	2.8 (1.3–6.0)	2.8 (1.3–6.2)
SIR	5	1.8 (1.4–2.3)	1.8 (1.4–2.3)
SMR	3	1.2 (0.7–1.9)	1.2 (0.7–1.9)
Europe	10	1.6 (1.2–2.1)	1.6 (1.2–2.1)
North America	2	1.8 (1.3–2.6)	1.8 (1.3–2.6)
Prostate cancer			
All studies	9	1.4 (1.1–1.8)	1.4 (1.1–1.8)
SIR	6	1.5 (1.1–1.9)	1.5 (1.1–1.9)
SMR	3	1.1 (0.7–1.8)	1.1 (0.7–1.8)
Europe	8	1.1 (0.8–1.5)	1.1 (0.8–1.5)

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Experimental background and available epidemiological data

In a brief publication (1) that appeared in December 2007, the IARC working group placed special emphasis on the following mechanistic findings with respect to a possible link between light exposure at unusual times and the development of cancer: Light during the “biological night” disturbs the circadian system, alters sleep-activity patterns, suppresses melatonin production, and deregulates circadian genes for cancer-related pathways. The IARC’s extensive monograph, which will contain further details of the classification of shift work with circadian disruption as a probable human carcinogen, still remains to be published.

When all of the relevant experimental findings in animals and cells are taken into account, it seems entirely plausible to postulate a mechanistic connection between shift work that involves chronic disturbances of biological 24-hour rhythms and a long-term risk of cancer (2–4). Still, the central question remains whether shift work with chronodisruption actually does have such effects in man. The available epidemiological findings to date can certainly shed light on this important issue.

Two general observations apply to all of the epidemiological studies that will be discussed further below:

- All of these studies took account of established and possible confounding variables, albeit in differing ways.
- It goes without saying that we will discuss all of the studies in this area that are known to us,

regardless of whether the evidence they provide about risk is positive, neutral, or negative.

Two mortality studies in England and Wales (e1) and in Iceland (e2) can be interpreted as providing initial historical evidence for the postulated cancer risk among shift workers. In the British cohort of 8603 shift workers and day workers, the shift workers had a significantly higher overall risk of cancer (e1). The Icelandic study concerned mortality among workers in the fertilizer industry; in a cohort of 603 workers (e2), an overall elevation of mortality due to cancer was observed with shiftwork operators having the highest standardized mortality rates (SMRs) for all cancers.

A few years ago, working groups at the universities of Cologne (Germany) and San Antonio (USA), working at the same time as the IARC but independently of it, systematically evaluated the available epidemiological studies to test the applicability of the biologically plausible experimental findings to human beings (4). Flight personnel and shift workers were chosen as the study populations because these occupational groups experience marked disturbances of their internal physiological clocks as the result of trans-meridian flights (i.e., flights across time zones), night work, and shift work.

Epidemiological studies published in peer-reviewed journals and containing information about cancer risks in flight personnel and shift workers, as well as on covariables of exposures and endpoints, were systematically identified by searching in Medline and the ISI Web of Knowledge. A total of 30 epidemiological studies were included in the final analyses on the subject of shift work, chronodisruption, and cancer; taken together, these studies involved a total study population of some 240 000 persons (ca. 70 000 flight personnel and 170 000 shift workers) (e3–e32). Key results of the meta-analyses employing established, standard statistical methods (5, 6) are summarized in *Tables 1 and 2* (4).

Tests of homogeneity, along with the nearly identical risk estimates that were found to result from meta-analyses with fixed and random effects, imply that no major statistical considerations contraindicate the pooling of results from multiple individual studies. A look at the overall estimates reveals that the risk findings are consistent with predictions of the chronodisruption-cancer theory (2): The empirical findings indicate that disturbances of the internal physiological clock by trans-meridian flights, night work, and rotating shift work may be associated with significantly elevated risks of breast and prostate cancer.

Nonetheless, because of differences among studies with respect to exposures to chronodisruption, and also with respect to the co-factors of the cancer endpoints that individual studies took into account, there remain at least doubts about whether the observed elevations of cancer risk can really be causally attributed to flights across time zones or to shift work. Incidentally, it should be pointed out in this context that the potential role of cosmic high-altitude radiation has been

extensively studied. According to a very recent evaluation of the pertinent epidemiological studies, this factor accounts for little or no elevation of the risk of cancer among flight personnel (e33).

A retrospective case-control analysis on night work (interview data) and the incidence of breast cancer, performed as part of the German GENICA study, revealed that women who indicated that they worked at night had no overall excess risk (7), although a statistically insignificant elevation of risk was observed among women who had performed night work for 20 or more years (odds ratio [OR] 2.48, 95% confidence interval [CI] 0.62–9.99).

Two studies on the risk of prostate cancer among shift workers (8, 9) documented an elevation of the cancer risk by a factor of 3.0 (95% CI: 1.2–7.7) and 1.3 (95% CI: 1.0–1.7), respectively. A very large cohort study by Schwartzbaum et al. (10) did not demonstrate any elevation of risk. The authors of this ecological study mentioned the possibly critical fact that the use of aggregate rather than individual data may have led to shift-work estimates being erroneously classified; this problem was also pointed out in an accompanying editorial (e34). Faulty estimates of this type might mask a real elevation of risk.

Beyond the risk of breast and prostate cancer, epidemiological studies have been performed on the risk of colorectal (11) and endometrial (12) cancer among night workers. The Nurses' Health Study, a prospective study that provided data for two breast cancer studies that were included in the meta-analyses (e29, e30), also revealed elevated risks for colorectal and endometrial carcinoma among nurses who had performed rotating shift work for 15 or more years (e29) (risk estimate 1.35, 95% CI 1.03–1.77) and for 20 or more years (e30) (risk estimate 1.47, 95% CI 1.03–2.10).

Epidemiological evaluations concerned not only the initially tested prediction that shift workers exposed to light at unusual times would have a higher risk of cancer, but also three further predictions that are logical consequences of the chronodisruption-cancer theory (2). The theory would lead one to expect that populations that are less exposed to light have a lower risk of cancer, i.e., that darkness is protective. In line with this prediction, the incidences of breast and prostate cancer in the Arctic have, indeed, been found to be low (e35–e37, 13), and the relevant literature on genetic, reproductive, nutritional, and lifestyle factors in the Arctic yields no other obvious explanation for this fact (13). Likewise, the incidence of breast cancer is lower in blind women (14–18; exception, 19) and in women with longer cumulative times at sleep over the course of their lives (20, 21; exception, 22). A single study revealed a lower incidence of prostate cancer among men who sleep at least nine hours per night (23) (risk estimate 0.48, 95% CI 0.29–0.79).

Thus, studies of the types just described have yielded findings that are consistent with predictions of the chronodisruption-cancer theory, yet these findings also hold further complications for the determination of causality

TABLE 2

Meta-analyses: shift workers and the risk of breast cancer (4)

	Number of studies	RR (95% CI), fixed effects	RR (95% CI), random effects
Breast cancer			
All studies	7	1.4 (1.3–1.6)	1.5 (1.2–1.8)
Cohort studies	2	1.4 (1.1–1.8)	1.4 (1.1–1.8)
Case-control studies	5	1.4 (1.2–1.7)	1.5 (1.1–2.0)
Europe	3	1.6 (1.3–1.8)	1.6 (1.2–2.2)
North America	4	1.3 (1.1–1.6)	1.4 (1.1–1.8)

(Reprinted with the kind permission of Springer Science + Business Media); RR, relative risk; CI, confidence interval

(2, e38). For example, all of the observational studies performed to date have failed to take account of, and to control for, possible interactions among multiple potential causal factors (e38). Aside from the specific conditions of shift work, exposure to noise during the biological night and geographically determined conditions of light exposure might be relevant for chronodisruption, which is the postulated key link in a causal chain leading to cancer.

Communication of “risk” and approaches to compensation

Four pillars of evidence need to be considered in risk assessment: hazard identification, dose-response assessment, exposure assessment, and risk characterization (e39). Thus far, the IARC working group has only answered the question whether shift work with chronodisruption raises the risk of cancer (“hazard identification”: “probably carcinogenic”) (1).

Nonetheless, the new IARC classification can be expected to generate uncertainty and worry among insurees in Germany and elsewhere (24, e40). 15% to 25% of all workers in Europe and the USA perform night work and shift work (1), and, among flight personnel, shift work and flights across time zones are practically unavoidable.

In general, the strength of a risk factor is determined by the prevalence of all causal factors that contribute to the causation of disease (e41). It follows from this premise that the risk factors identified to date for breast and prostate cancer are weak. The fact that shift work, and the chronodisruption potentially associated with it, are widespread in the population might have the consequence that this “probable human carcinogen” is actually a strong risk factor for cancer (4). It has not yet been conclusively demonstrated, however, that shift work with circadian disruption or chronodisruption promotes the development of cancer, and we therefore consider an assessment of cancer cases possibly attributable to this particular risk factor to be speculative and inappropriate at present.

With regard to theoretically conceivable approaches to compensation, the first compensatory awards were granted in 2008 to 38 Danish women who worked the night shift and developed breast cancer (e40, e42), and the inclusion of night-shift work in the list of compensable occupational illnesses in Denmark is now under evaluation. This approach toward recognition and compensation has touched off intense debate in Australia, New Zealand, Asia, and North America, and especially in England, the Netherlands, and Belgium. The matter was also debated at last year's annual meeting of the German Society for Occupational and Environmental Medicine (*Deutsche Gesellschaft für Arbeits- und Umweltmedizin*) in Aachen (e43).

In Germany, a condition can only be legally recognized as an occupational illness "if the postulated causal relationship is documented beyond any doubt." This condition is not fulfilled in the present case. Nor are the conventional requirements of a doubling of risk (e44) and of a positive dose-effect relationship, which are in effect not only in Germany (e45), but also in the United Kingdom (e46), Canada (e47), and the USA (e44).

Prevention

Shift work and chronobiology have a longstanding tradition of successful research behind them, particularly in Germany, where Rutenfranz and Aschoff were among the prominent figures in this area. Nonetheless, the question whether shift work contributes to the development of cancer by way of circadian disruption or chronodisruption is very new, and relatively few studies have been carried out with a view toward practical preventive measures.

Appropriate information should be provided about the current state of the scientific data on the biologically plausible causal relationships between shift work, chronodisruption, and cancer, and about the current limitations and uncertainties of research in this area (24, e40).

The German Law on Working Hours (*Arbeitszeitgesetz*) specifies that the working hours of night workers and shift workers must be set in accordance with the relevant definitive findings of occupational science. In view of the biologically plausible links between shift work, chronodisruption, and cancer, occupational physicians and shift-work researchers should determine what type of shift plan would be most suitable for keeping chronodisruption to a minimum, as required by the principle of "prudent avoidance," and should then use this knowledge to persuade employees of the health advantages of changing their shift plans accordingly. Wherever a choice of options is possible, shift and flight personnel should be asked about their sleep preferences (e48). Thus, shift planning might take account of individual characteristics (chronotypes), giving different schedules to "voluntary" early risers ("larks," the most common normal type in the general population) and late risers ("owls"). "Owls" find night shifts to be much less of a burden than "larks" do, but

assigning "owls" to permanent night shifts would be an unacceptable solution (25).

The tolerance for chronodisruption changes over the course of an individual's life, and a preventive strategy ought to take this fact into account. Insight into the matter can be gained by asking workers the following question: "Compared to other employees of your age, how well do you cope with shift work and flights across time zones—very well, acceptably well, or not well at all?" (4). In fact, many affected persons become less able to cope with shift work as they grow older.

In general, preventive measures against chronodisruption might protect shift workers not just from the putative risks of cancer, but also from other short- and intermediate-term health problems, such as insomnia and gastrointestinal disturbances. Even though it seems unlikely that an individual marker for potentially elevated cancer risks will become available any time soon, preventive occupational medicine check-ups can have a protective effect (24). The German Law on Working Hours gives shift workers the legal right to free occupational medicine examinations and counseling before they commence shift work, once every three years thereafter up to age 50, and then annually from age 50 onward.

Traditional shift plans involving weeklong shifts that rotate backwards in time (with the night shift followed by the late shift, and then the early shift) are still quite common, even though recent insights in occupational medicine show they are suboptimal (25). The body cannot accommodate fully to night work in a single week on the night shift, but can only do so partially (e49). When the week on the night shift is over, the body needs several more days to become re-entrained. On the other hand, shorter night shift periods cause a less severe disturbance of the worker's daily rhythm and less severe chronodisruption. Thus, if one would like to keep the daily rhythm as close to normal as possible despite working the night shift, and thereby spare the body unnecessary readjustment work, then the night-shift periods should be kept as short as possible. It has been found that adherence to the recommendations of occupational science regarding shift planning (e49) yields favorable effects on health, on risk factors for cardiovascular disease (e51), and on the subjective assessment of health (work ability index) (e50).

In the authors' view, the notion that shift workers should be shielded from the light spectrum that is relevant to the endocrine system (wavelength 460 to 480 nanometers) through the use of suitably designed light sources, or of filtering eyeglasses or lenses, has not been adequately studied to date, for example, with respect to a potential effect on attentiveness (e52). From a theoretical point of view, this approach seems reductionistic and not timely, given that a multitude of zeitgebers are now known to play a role in setting the shift worker's internal physiological clock (e38, e53).

Perspectives

Based on the experience to date, the International Agency for Research on Cancer can be expected to

perform another assessment of this subject in a few years. It is entirely possible that the next evaluation will lead to a reclassification of shift work as a group 1 carcinogen, if multiple new studies with positive findings are published by then. This would put shift work in the same class as, for example, cigarette smoke, asbestos, arsenic, and ionizing radiation. Such classification was—according to personal communications from several experts in the IARC panel—already contemplated in 2007.

We find it problematic that, for two reasons, risk studies with positive findings are more likely to be considered than others, thereby creating a misleading effect. One reason is that, as experience shows, positive studies are more likely to be published (e54). Note that the IARC exclusively considers study findings that have already been published, or accepted for publication, in peer-reviewed journals by the time that the expert panel convenes. The other is that population-based case-control studies in which the shift-work history is obtained through an interview or questionnaire tend to generate risk estimates that are biased in the positive direction, not just because of selection bias, but also because a suspect exposure is more likely to be recalled after the subject has experienced an outcome that is considered potentially attributable to it, such as cancer (e55).

Studies of this type can be carried out relatively rapidly, and we can therefore expect a good number of them to become available by the time the IARC performs its next evaluation of shift work, chronodisruption, and cancer. A highly illustrative example of biases of this kind appeared in the setting of the long-standing debate about the potential risk of breast cancer from passive smoking (e56): Here, 17 studies in which data on exposures were collected retrospectively misleadingly suggested a possible cause-and-effect relationship, with a statistically significant elevation of relative risk by a factor of about 1.2.

Interestingly, after we had completed our literature search (2009), a new epidemiological study on night-shift work and the risk of breast cancer was published by Chinese researchers in April 2010 (e57). In this prospective, population-based cohort study, night-shift work—which was reconstructed both with a job-exposure matrix and through interviews of subjects—was not found to be associated with a higher risk of breast cancer (risk estimate 0.9, 95% CI 0.7–1.1).

Taken together, all of the results presented here indicate that major challenges lie ahead in determining the proper ways to deal with the postulated, biologically plausible causal relationships between highly prevalent shift-work conditions on the one hand, and very common cancer endpoints on the other.

Erroneous decisions in this matter should be avoided. Thus, even though the questions confronting physicians in clinical practice now seem urgent, it must remain a central goal that robust epidemiological studies be performed that will be comparable with one another and that will permit valid conclusions about causality.

KEY MESSAGES

- In 2007, the International Agency for Research on Cancer, a body that is part of the World Health Organization, classified shift work with circadian disruption or chronodisruption as a probable human carcinogen.
- The theory that chronic disturbance and disruption of coupled circadian rhythms that normally run in parallel over time (chronodisruption) might increase the risk of cancer over the long term is relatively new.
- Experimental findings make the postulated causal relationships between shift work and cancer in human beings biologically plausible; nonetheless, no epidemiological studies to date have conclusively described risk factors of this type in human beings, nor have any studies conclusively ruled them out.
- In Denmark, in 2008, 38 women with breast cancer who had worked the night shift obtained official recognition of the occupational causation of their illness and were awarded monetary compensation. In Germany, however, the law on occupational diseases specifies that certain scientific requirements for the recognition of so-called “general suitability” must be met before a new occupational disease can be defined. At present, these requirements are not met.
- Even though the current state of scientific knowledge does not permit a firm conclusion that shift work increases the risk of cancer, prudence requires that shift planning should make more extensive use of the pertinent insights that have been gained in the fields of occupational medicine, chronobiology, and occupational science.

Conflict of interest statement

The authors declare that they have no conflict of interest as defined by the guidelines of the International Committee of Medical Journal Editors.

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REFERENCES

1. Straif K, Baan R, Grosse Y, et al.: Carcinogenicity of shift-work, painting, and fire-fighting. *Lancet Oncol* 2007; 8: 1065–6.
2. Erren TC, Reiter RJ: A generalized theory of carcinogenesis due to chronodisruption. *Neuro Endocrinol Lett* 2008; 29: 815–21.
3. Erren TC, Reiter RJ: Defining chronodisruption. *J Pineal Res* 2009; 46: 245–7.
4. Erren TC, Pape HG, Reiter RJ, Piekarski C: Chronodisruption and cancer. *Naturwissenschaften* 2008; 95: 367–82.
5. Greenland S: Quantitative methods in the review of epidemiologic literature. *Epidemiol Rev* 1987; 9: 1–30.
6. DerSimonian R, Laird N: Meta-analysis in clinical trials. *Control Clin Trials* 1986; 3: 177–88.
7. Pesch B, Harth V, Rabstein S, et al.: Night work and breast cancer – results from the German GENICA study. *Scand J Work Environ Health* 2009; 29: 23.

8. Kubo T, Ozasa K, Mikami K, et al.: Prospective cohort study of the risk of prostate cancer among rotating-shift workers: findings from the Japan collaborative cohort study. *Am J Epidemiol* 2006; 164: 549–55.
9. Conlon M, Lightfoot N, Kreiger N: Rotating shift work and risk of prostate cancer. *Epidemiology* 2007; 18: 182–3.
10. Schwartzbaum J, Ahlbom A, Feychting M: Cohort study of cancer risk among male and female shift workers. *Scand J Work Environ Health* 2007; 33: 336–43.
11. Schernhammer ES, Laden F, Speizer FE, et al.: Night-shift work and risk of colorectal cancer in the nurses' health study. *J Natl Cancer Inst* 2003; 95: 825–8.
12. Viswanathan AN, Hankinson SE, Schernhammer ES: Night shift work and the risk of endometrial cancer. *Cancer Res* 2007; 67: 10618–22.
13. Erren TC, Piekarski C: Does winter darkness in the Arctic protect against cancer? The melatonin hypothesis revisited. *Med Hypotheses* 1999; 53: 1–5.
14. Hahn RA: Profound bilateral blindness and the incidence of breast cancer. *Epidemiology* 1991; 2: 208–10.
15. Feychting M, Osterlund B, Ahlbom A: Reduced cancer incidence among the blind. *Epidemiology* 1998; 9: 490–4.
16. Verkasalo PK, Pukkala E, Stevens RG, Ojamo M, Rudanko SL: Inverse association between breast cancer incidence and degree of visual impairment in Finland. *Br J Cancer* 1999; 80: 1459–60.
17. Kliukiene J, Tynes T, Andersen A: Risk of breast cancer among Norwegian women with visual impairment. *Br J Cancer* 2001; 84: 397–9.
18. Pukkala E, Ojamo M, Rudanko SL, Stevens RG, Verkasalo PK: Does incidence of breast cancer and prostate cancer decrease with increasing degree of visual impairment. *Cancer Causes Control* 2006; 17: 573–6.
19. Pukkala E, Verkasalo PK, Ojamo M, Rudanko SL: Visual impairment and cancer: a population-based cohort study in Finland. *Cancer Causes Control* 1999; 10: 13–20.
20. Verkasalo PK, Lillberg K, Stevens RG, et al.: Sleep duration and breast cancer: a prospective cohort study. *Cancer Res* 2005; 65: 9595–600.
21. Kakizaki M, Kuriyama S, Sone T, et al.: Sleep duration and the risk of breast cancer: the Ohsaki Cohort Study. *Br J Cancer* 2008; 99: 1502–5. Epub 2008; Sep 23.
22. Pinheiro SP, Schernhammer ES, Tworoger SS, Michels KB: A prospective study on habitual duration of sleep and incidence of breast cancer in a large cohort of women. *Cancer Res* 2006; 66: 5521–5.
23. Kakizaki M, Inoue K, Kuriyama S, et al.: Sleep duration and the risk of prostate cancer: the Ohsaki Cohort Study. *Br J Cancer* 2008; 99: 176–8. Epub 2008; Jun 10.
24. Erren TC, Morfeld P, Stork J, et al.: Shift work, chronodisruption and cancer?—the IARC 2007 challenge for research and prevention and 10 theses from the Cologne Colloquium 2008. *Scand J Work Environ Health* 2009; 35: 74–9.
25. Seibt A, Knauth P, Griefahn B: Arbeitsmedizinische Leitlinie der Deutschen Gesellschaft für Arbeitsmedizin und Umweltmedizin e.V., Nacht- und Schichtarbeit, Arbeitsmedizin – Sozialmedizin – Umweltmedizin (ASU) 2006: 41(8): 390–7. <http://www.dgaum.med.uni-rostock.de/leitlinien/NachtuSchichtarbeit%20280205.pdf>

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